IV. DRAFT EMFAC2000 MODEL ANALYSIS

ARB's development of the draft EMFAC2000 model represents the culmination of more than ten years of effort on the part of the staff to refine and improve the accuracy of the on-road emissions inventory. Emission models are the only way to estimate the future year effectiveness of the Enhanced I/M program, and the draft EMFAC2000 represents our best tool for emission modeling at this time.

Draft EMFAC2000 models the effectiveness of I/M based on past evaluations of the I/M program, including the 1984 I/M evaluation program conducted from 1984 to 1989, the 1990 I/M evaluation program conducted from 1991 to 1994, and the 1994 California Pilot I/M Program (1994 pilot program), which evaluated the potential effectiveness of California's hybrid Enhanced I/M program.[1] Draft EMFAC2000 uses the results of these evaluation programs to model the identification rate (the fraction of vehicles that fail their Smog Checks), repair effectiveness (how well failing vehicles are repaired), and vehicle deterioration (how emission rates of vehicles increase over time as they age). For vehicles equipped with on-board diagnostic (OBD) II systems, draft EMFAC2000 assumes a successful repair because a successful repair is necessary in order to turn off the "check-engine" light. Draft EMFAC2000 includes assumptions about I/M program avoidance (vehicles that do not receive their required smog checks) which are based on review of Department of Motor Vehicle files and parking lot surveys in the South Coast Air Basin. Further description of how draft EMFAC2000 models the I/M program can be found in "Section 9.0 - Methodology Used to Model Inspection and Maintenance Programs" of the EMFAC2000 draft technical support documentation.[1]

A. <u>Comparison of Draft EMFAC2000 and Roadside Data</u>

Because the draft EMFAC2000 results for 1999 are reasonably close to the roadside results, we believe that it is appropriate to use draft EMFAC2000 to model the I/M program effectiveness in future years. Table IV-1 provides a side-by-side comparison of the roadside analysis to the draft EMFAC2000 fleet average emission rates. The roadside "Before ASM" results are compared to the draft EMFAC2000 output for the 1990 Basic I/M program, and the roadside "After ASM" results are compared to the draft EMFAC2000 output for the current Enhanced I/M program. As can be seen, the observed/calculated results using roadside and the predictions from draft EMFAC2000 are fairly close.

Table IV-2 shows the percent reduction in fleet average emission rate for both draft EMFAC2000 and the 1998-1999 roadside testing. The percent reduction modeled by draft EMFAC2000 is very similar to the percent reduction shown by roadside testing for NOx and somewhat higher than roadside for HC and CO. The values shown are for the fleet tested in the roadside program – the fleet of gasoline-powered light-duty passenger cars, light-duty trucks, and medium-duty vehicles. Although heavy-duty

[1] Reference: Section 9.0 Methodology Used to Model Inspection and Maintenance Programs of EMFAC2000 draft technical support documentation, 2/1/2000, available at www.arb.ca.gov/msei/doctable.htm.

gasoline vehicles are included in the I/M program (they receive idle tests only), they are not included in the averages compared in Table IV-2 because they were not included in the roadside testing. The values shown represent the percent reduction in fleet average emission rate in gram per mile from 1990 Basic I/M to Enhanced I/M.

Table IV-1
Comparison of Roadside and Draft EMFAC2000[1] [g/mi]
(1999)

	$HC_{exhaust}$		NOx		CO	
	Roadside	**EMFAC2000**	**Roadside**	**EMFAC2000**	**Roadside**	**EMFAC2000**
Before ASM (90 Basic I/M)	**1.19**	**0.93**	**0.94**	**0.82**	**13.7**	**11.8**
After ASM (Current Enhanced)	**1.03**	**0.75**	**0.89**	**0.77**	**12.1**	**9.7**

[1] The draft EMFAC2000 emission rates cited here are for the fleet of light-duty passenger cars, light-duty trucks, and medium-duty vehicles. NOx was set at gross-polluter cut points.

Table IV-2
Comparison of Percent Reduction
in Exhaust Emission Rate due to Enhanced I/M
Derived from Roadside Testing vs.
That Derived from Draft EMFAC2000 (1999)

	$HC_{exhaust}$	NOx	CO
Roadside	13%	6%	12%
EMFAC2000[1]	19%	6%	18%

[1] Draft EMFAC2000 NOx values are based on gross polluter cut points.
The values shown represent the percent reduction in fleet average emission rate in gram per mile from Basic to Enhanced I/M. Values shown are for the fleet of gasoline-powered light-duty passenger cars, light-duty trucks, and medium-duty vehicles.
Because this table compares roadside percent reduction to draft EMFAC2000 percent reduction, the roadside values shown use the roadside test data for each model year together with the draft EMFAC2000 travel fractions. For 1994 SIP currency purposes, the roadside test data for each model year was applied to the EMFAC7F travel fractions, rather than the draft EMFAC2000 travel fractions. This resulted in slightly different percent reductions: 12% HC, 6% NOx, and 10% CO.

As a simplifying assumption, the calculations for 1999 using roadside data and the EMFAC2000 runs used to predict Smog Check effectiveness in future years assume that a full biennial cycle of loaded mode testing had occurred by the end of 1999. To the extent that less than a full cycle had been completed by 1999, the calculations may overstate the actual reductions. However, for the 1999 calculations based on roadside, this effect is at least partially offset by the fact that we did not account for the benefits from implementing more stringent NOx cut points in October 1999.

B. Draft EMFAC2000 Modeling Runs

To evaluate the effectiveness of the Enhanced I/M program in reducing HC, NOx, and CO emissions, we ran the draft EMFAC2000 model for the following scenarios:

1) **No I/M** – Emissions that would result if no I/M program were in effect, but the on-board diagnostic program were in existence.

2) **90 Basic I/M** (90 I/M as represented in EMFAC 7F and 1994 SIP) -

- Biennial testing;
- BAR-90 test, i.e., 2-speed idle testing;
- Full visual and functional test;
- Vehicles included (gasoline-powered passenger cars (PC), light-duty trucks (LDT), medium-duty vehicles (MDV), and heavy-duty trucks (HDGT));
- No evaporative system test;
- Measure HC and CO only;
- 1966 and newer vehicles included, 2 years before inspection of new cars;
- Repair cost waiver at $50-300, depending on age;
- All stations are test-and-repair; and
- Two-speed idle cut points (as in California Code of Regulations, Title 16, Section 3340.42 Table III).

3) **Current Enhanced** (Enhanced program as currently implemented) –

- Biennial testing of all vehicles, including gross polluters;
- BAR-97 test, i.e., loaded-mode testing for gasoline-powered PC, LDT, MDV ≤ 8,500 pound (lb) gross vehicle weight (GVW);
- BAR-90, i.e., idle test for HDGT (>8,500 lb GVW);
- Full visual and functional test (no functional test of exhaust gas recirculation (EGR));
- Vehicles included (PC, LDT, MDV, and HDGT);
- Gas cap pressure test;
- Measure HC, CO, and NOx (loaded-mode testing);
- Exempt 4 year and newer vehicles, exempt 1973 and older vehicles until 2003, at which time anything older than 30 years will be exempted;
- Repair cost waiver at $450 (or $250 through economic hardship extension);
- Gross polluters eligible for repair cost waiver;
- Repair assistance and vehicle retirement program;
- Both Test and Repair and Test-Only stations, 15 percent of vehicles sent to Test-Only;
- Electronic transmission of smog-check results; and
- For 1999 - NOx cut points at gross polluter levels; for subsequent years - current cut points instituted in October 1999 (assumes that a full biennial cycle of loaded mode testing at current cut points had occurred by the end of 1999).

4) **94 SIP Enhanced** (This is meant to represent the Enhanced program that California designed to be equivalent to the U.S. EPA performance standard and that when modeled resulted in 112 tons per day of reductions in 1999.) –

- Biennial testing, and annual testing for gross polluters;
- BAR-97 test, i.e., loaded-mode testing (for PC, LDT, and MDV ≤ 8,500 lb GVW);
- BAR-90 idle test for HDGT (>8,500 GVW);
- Full visual and functional test (no functional test of EGR);
- Vehicles included (PC, LDT, MDV, and HDGT);
- Gas cap/helium test at least equivalent in performance to U.S. EPA pressure/purge;
- Measure HC, CO, and NOx;
- No vehicle year exemptions (tests 1966 through current model year vehicles);
- Repair cost waiver at $450;
- No waivers for gross polluters;
- Both Test and Repair and Test-Only stations, 30 to 40 percent of vehicles sent to Test-Only; and
- ARB cut points, i.e., cut points envisioned in 94 SIP runs showing 112 tons per day reductions in 1999.

C. Draft EMFAC2000 Output: Exhaust Emissions

Figures IV-1 through IV-9 plot the average emission rates that draft EMFAC2000 predicts for years 1999 to 2010 for the 90 Basic I/M program, the current Enhanced I/M program, and the 94 SIP Enhanced I/M program described above. Figures IV-1 through IV-3 show emission rates for light-duty passenger cars for exhaust HC, NOx, and CO, respectively. Figures IV-4 through IV-6 show emission rates for light-duty trucks for exhaust HC, NOx, and CO, respectively. Figures IV-7 through IV-9 show emission rates for medium-duty trucks for exhaust HC, NOx, and CO, respectively.

As Figures IV-1 through IV-9 illustrate, Enhanced I/M reduces emissions significantly below the 90 Basic I/M levels. The average emission rates for HC, NOx, and CO drop over time. NOx emissions for the current Enhanced program are much higher in 1999 than in 2000 because in 1999, draft EMFAC2000 was run for approximate gross polluter cut points, which were in effect at the time. BAR lowered NOx cut points in October 1999. To reflect this, in 2000 and subsequent years, draft EMFAC2000 was run for the current, more stringent NOx cut points. Chapter V describes how these draft EMFAC2000 model runs were used to determine the effectiveness of the program as compared to the 1994 SIP. We also ran draft EMFAC2000 for a hypothetical case – if the current HC and NOx cut points had been in effect for all of 1999 – as the basis for analyzing program improvement options in Chapter VI.

D. Draft EMFAC2000 Model for Evaporative Emissions

We also ran the draft EMFAC2000 model to estimate the effect of gas cap testing on evaporative HC emissions. Although the California Bureau of Automotive Repair is working on an analysis of gas cap testing effectiveness, the results of this analysis were not available at the time this report was prepared. We compared the evaporative HC emissions that draft EMFAC2000 shows for two scenarios:

(1) Gas cap testing is conducted; versus
(2) No gas cap testing is conducted.

We ran both scenarios for a date two years after gas cap testing is first implemented – one complete biennial Smog Check cycle.

The model shows that the fleet average gram per mile evaporative HC emission rate is 12 percent lower in the gas cap testing scenario than in the no-gas cap testing scenario. We applied this 12 percent reduction to all vehicle types subject to gas cap testing. As a simplifying assumption, we assumed that a full biennial cycle of gas cap testing had been completed by the end of 1999.

When gas cap testing was first implemented in June 1998, there was a big pool of broken or missing gas caps in the fleet. We expect that nearly all of these gas cap problems will be found in the first few years of gas cap testing. After gas cap testing has been in place for more than two years, we expect that very few bad gas caps will be found. Thus, we expect that the 12 percent benefit of gas cap testing below the "no gas cap testing" case, which results from the gas cap repairs made in the first few years gas caps are tested, to remain constant over time.

In addition to gas cap testing, On-Board Diagnostic (OBD) systems, which are incorporated into the computers on new vehicles to monitor components and systems that affect emissions when malfunctioning, help reduce evaporative emissions. If a problem is detected, the OBD II system illuminates the Malfunction Indicator Lamp (i.e., "check engine" light) on the vehicle instrument panel to alert the driver. California's second generation of OBD requirements (known as OBD II) has been in effect since the 1996 model year. OBD II requires essentially all vehicles in model year 1998 and newer to have evaporative system leak detection (Title 13, Section 1968.1(b) 4.0). This evaporative system leak detection performs a pressure test on the vehicles' evaporative system and is able to detect leaks from holes as small as 0.040 inches in diameter. Thus, as time goes on, a greater and greater portion of the light- and medium-duty vehicle fleet will have on-board diagnostics capable of detecting problems with vehicles' evaporative systems.

The OBD II system works in concert with Smog Check. If a vehicle's check engine light is on for evaporative emissions system failure when the vehicle goes for a smog check, in order to pass the inspection, it will need to have the evaporative system repaired. To estimate the effect of the increased portion of the fleet having OBD II, we used the draft EMFAC2000 model to estimate the portion of evaporative HC emissions due to vehicles with OBD II in each year. We assumed that vehicles with OBD II would meet the 94 SIP performance standard for evaporative emission control. We assumed that vehicles without OBD II would have their evaporative HC emissions reduced 12 percent by gas cap testing.

Figure IV-1
Passenger Car Exhaust Hydrocarbon Emission Rates, EMFAC2000

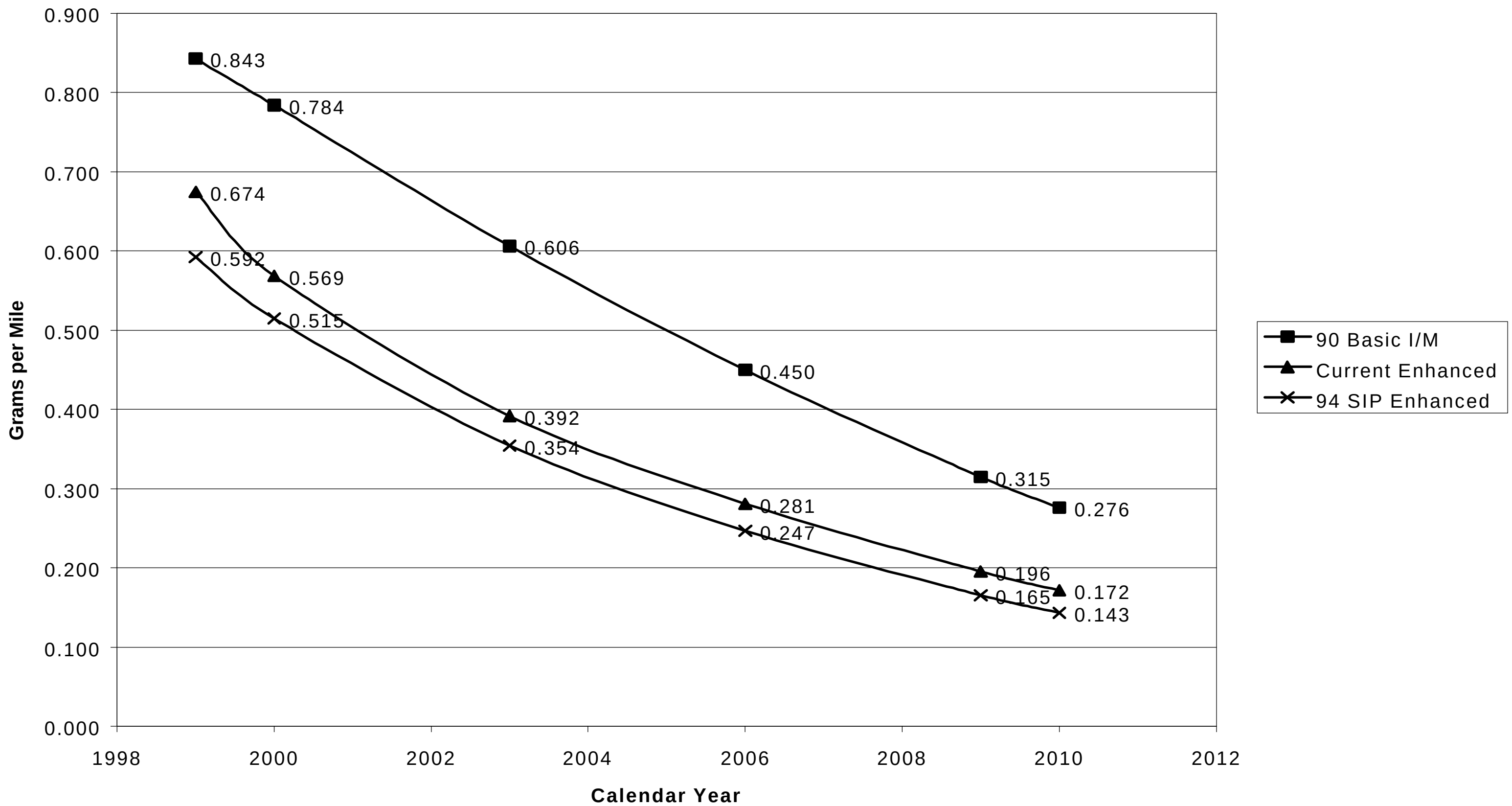


Figure IV-2

Passenger Car NOx Emission Rates, EMFAC2000

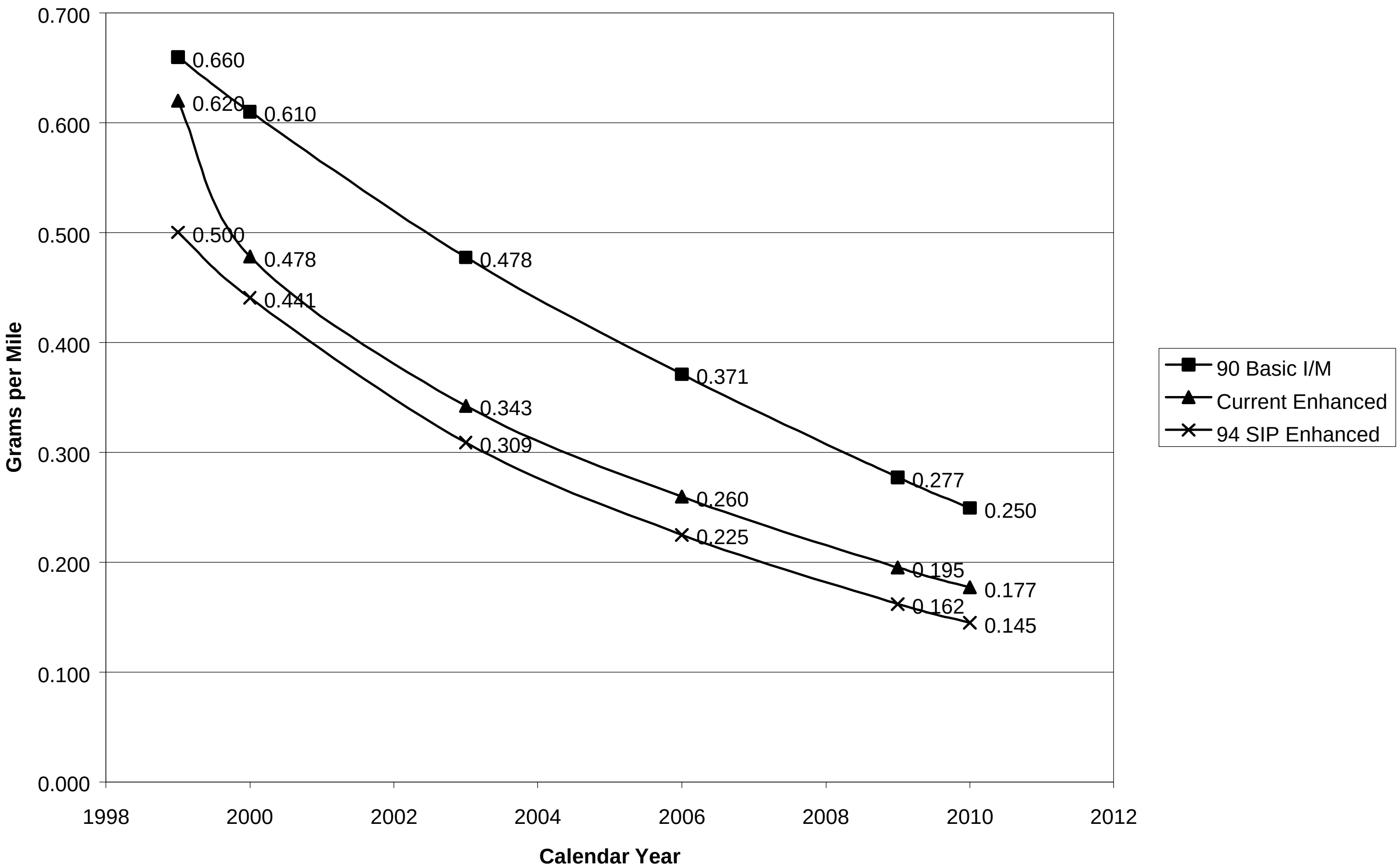


Figure IV-3
Passenger Car CO Emission Rates, EMFAC2000

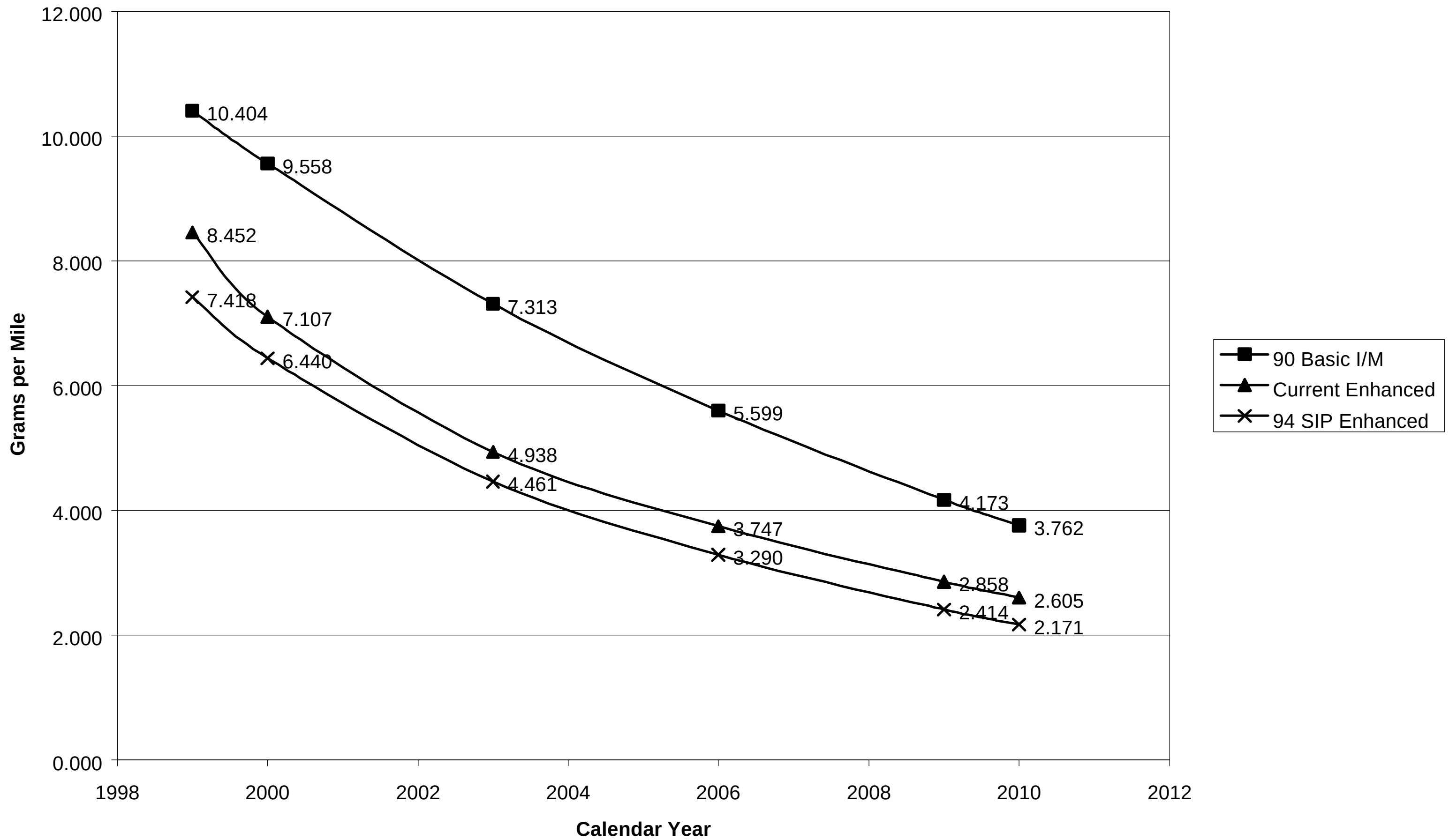


Figure IV-4

Light-Duty Truck HC Exhaust Emission Rates, EMFAC2000

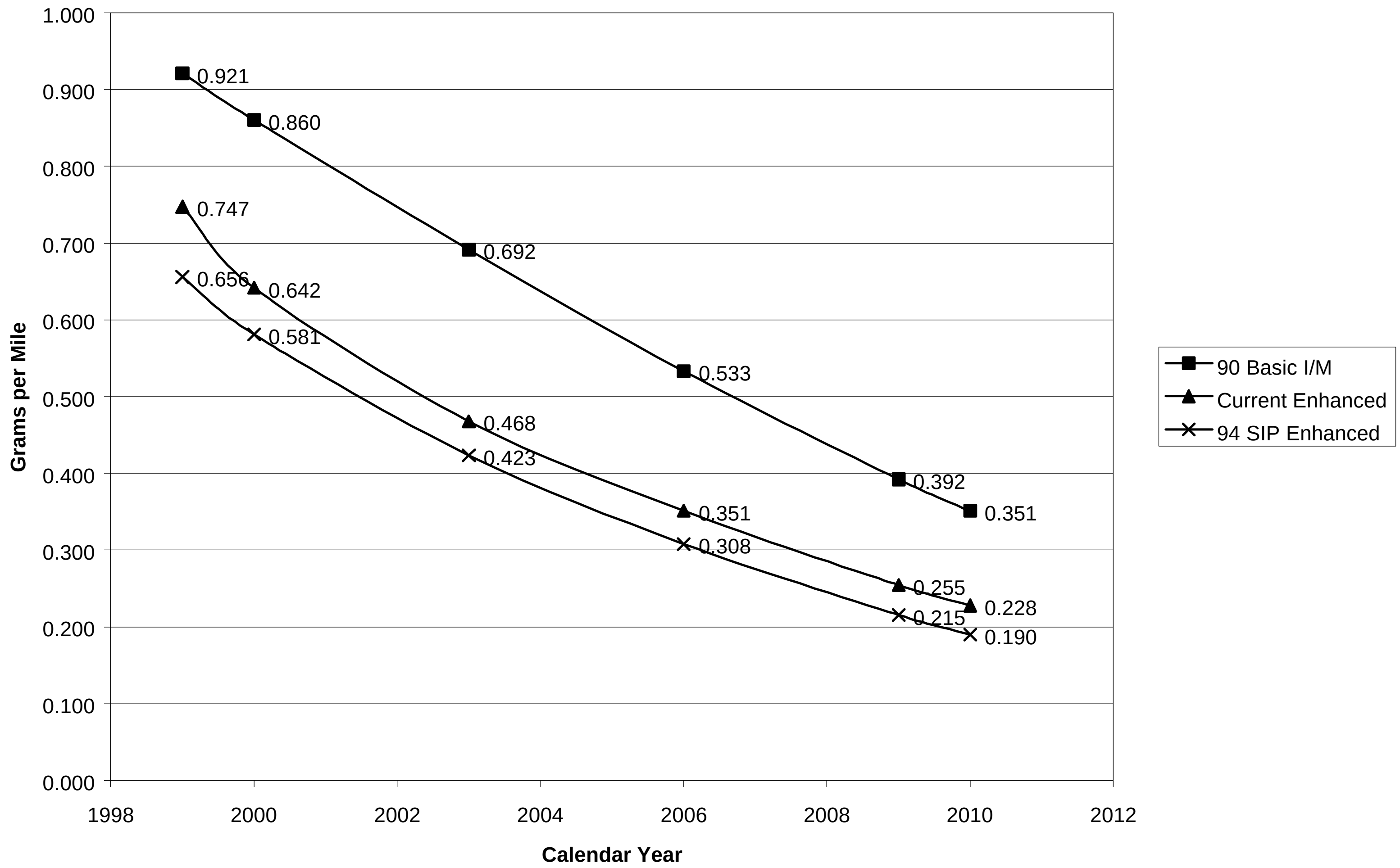


Figure IV-5

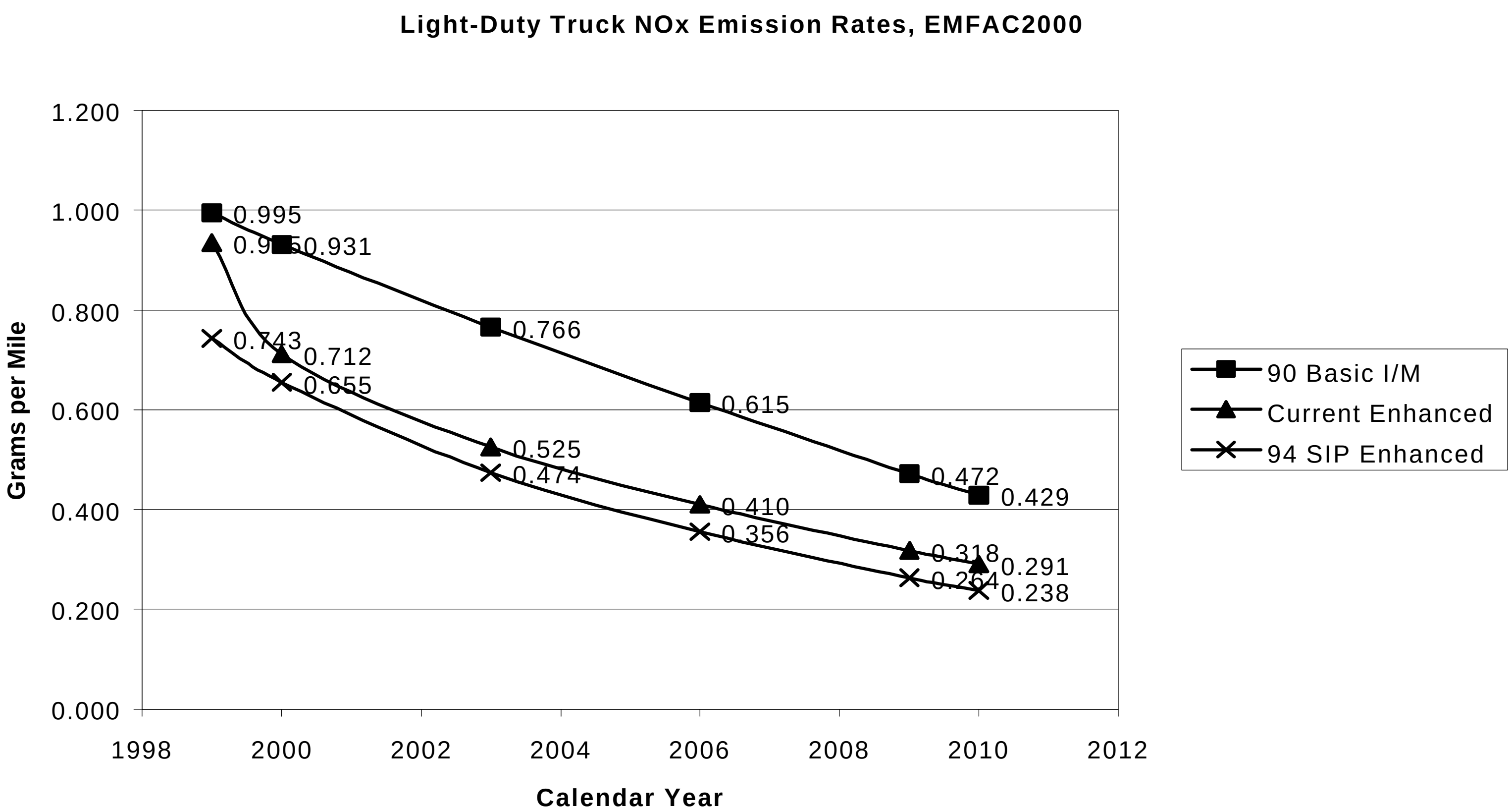

Light-Duty Truck NOx Emission Rates, EMFAC2000
Grams per Mile
Calendar Year
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1998
2000
2002
2004
2006
2008
2010
2012
0.995
0.931
0.766
0.615
0.472
0.429
0.931
0.712
0.525
0.410
0.318
0.291
0.743
0.655
0.474
0.356
0.264
0.238
90 Basic I/M
Current Enhanced
94 SIP Enhanced

Figure IV-6

Light-Duty Truck CO Exhaust Emission Rates, EMFAC2000

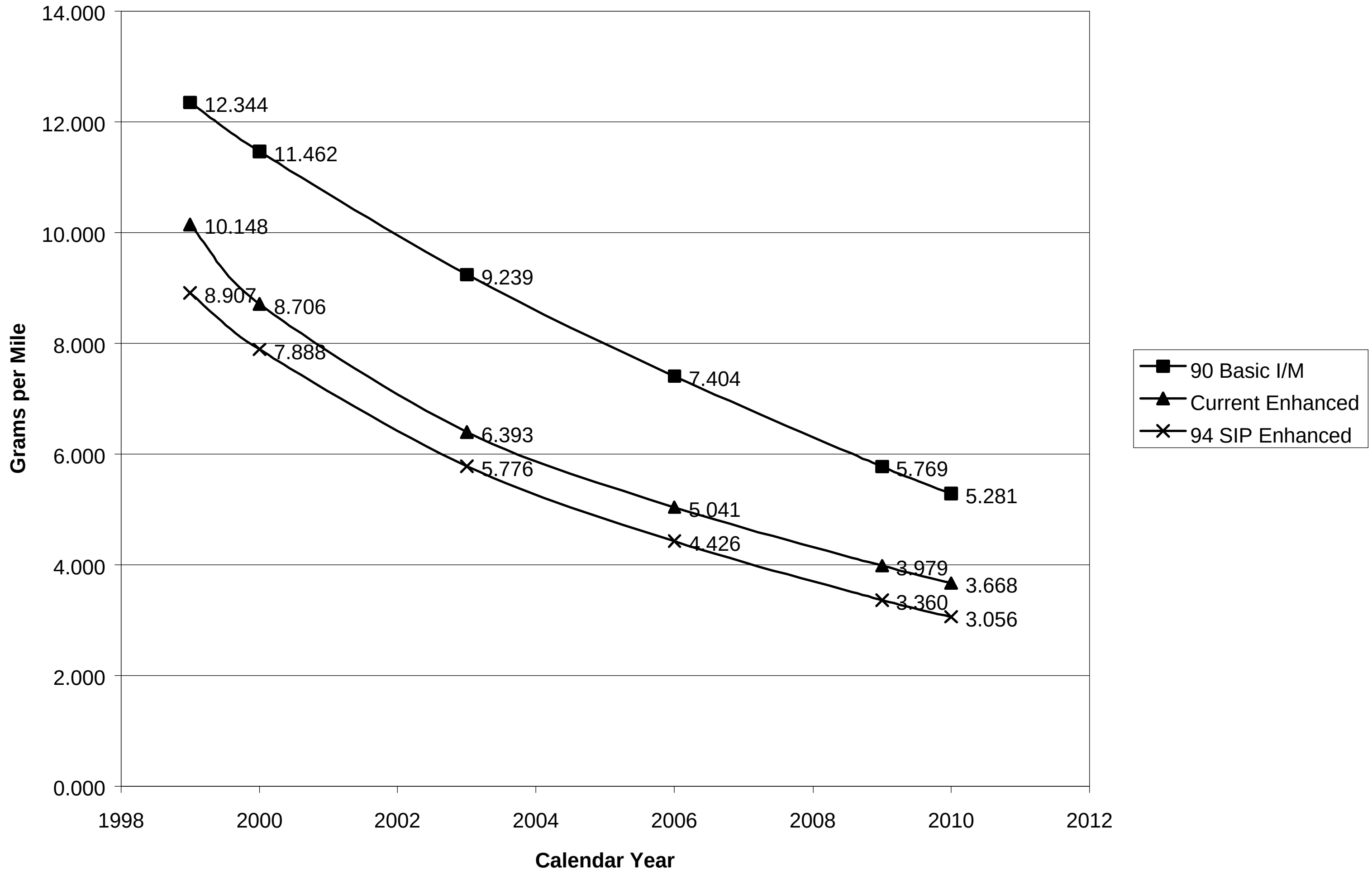
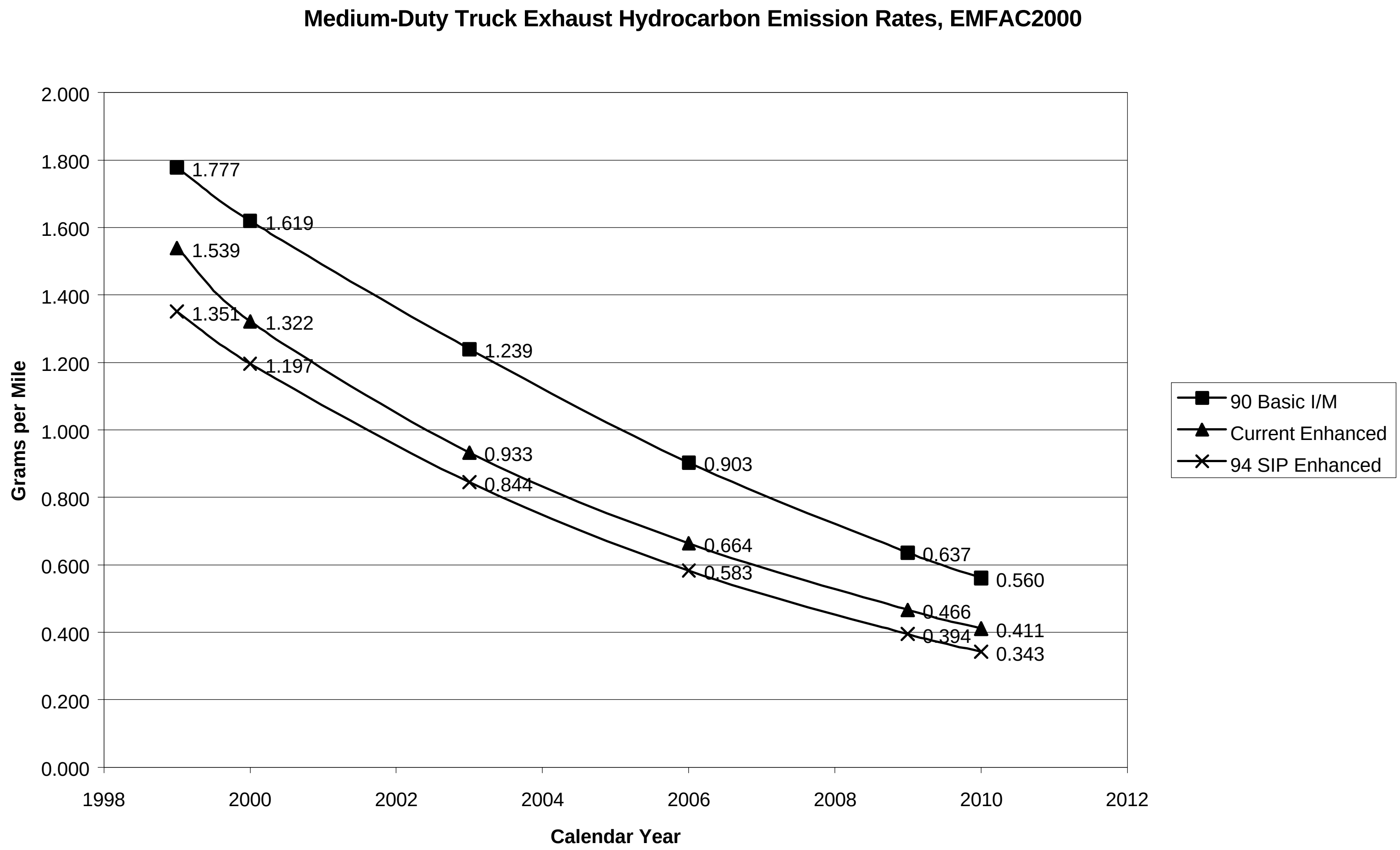


Figure IV-7



Medium-Duty Truck Exhaust Hydrocarbon Emission Rates, EMFAC2000
Grams per Mile
Calendar Year
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1998
2000
2002
2004
2006
2008
2010
2012
1.777
1.619
1.239
0.903
0.637
0.560
1.539
1.322
0.933
0.664
0.466
0.411
1.351
1.197
0.844
0.583
0.394
0.343
90 Basic I/M
Current Enhanced
94 SIP Enhanced

Figure IV-8

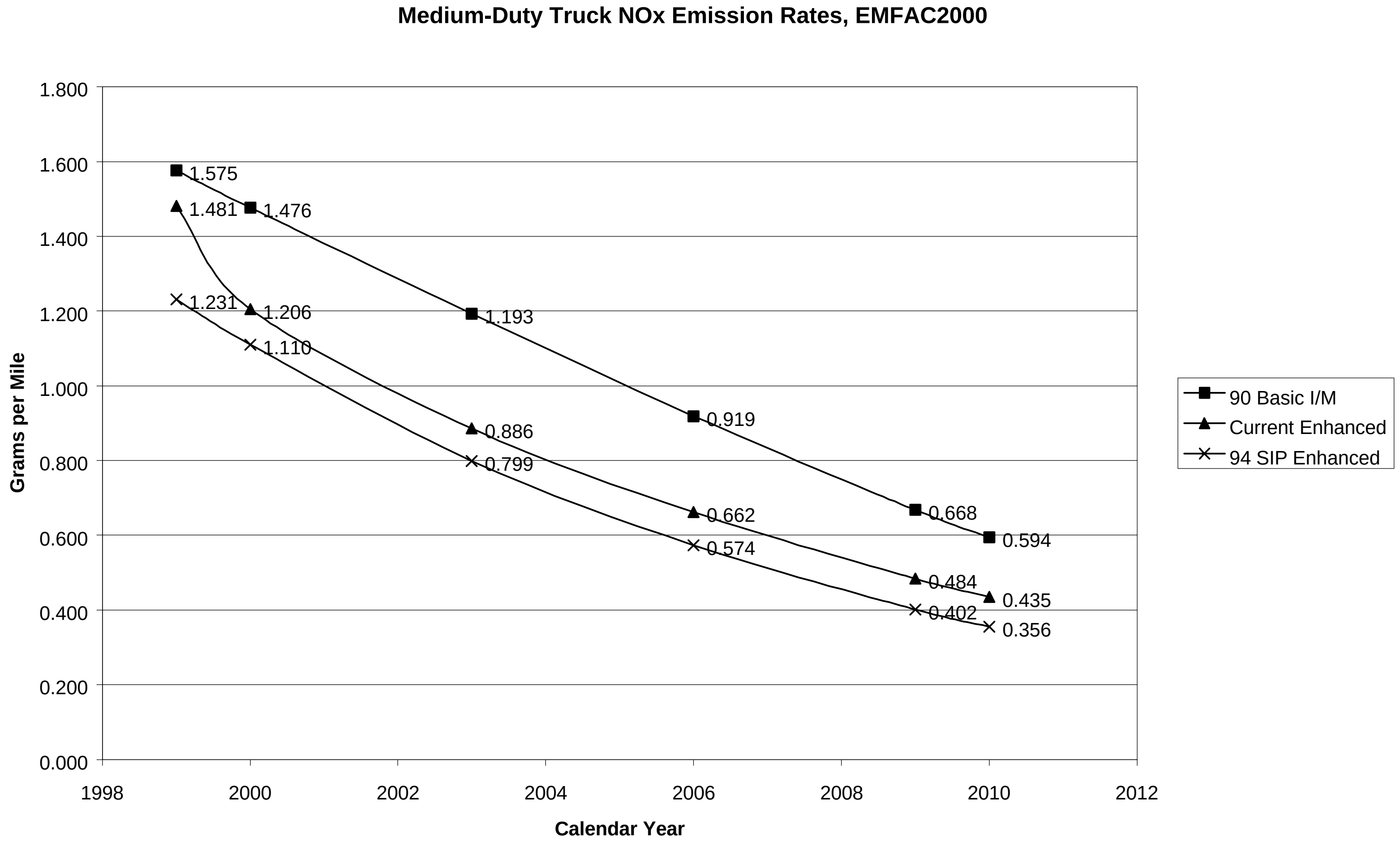
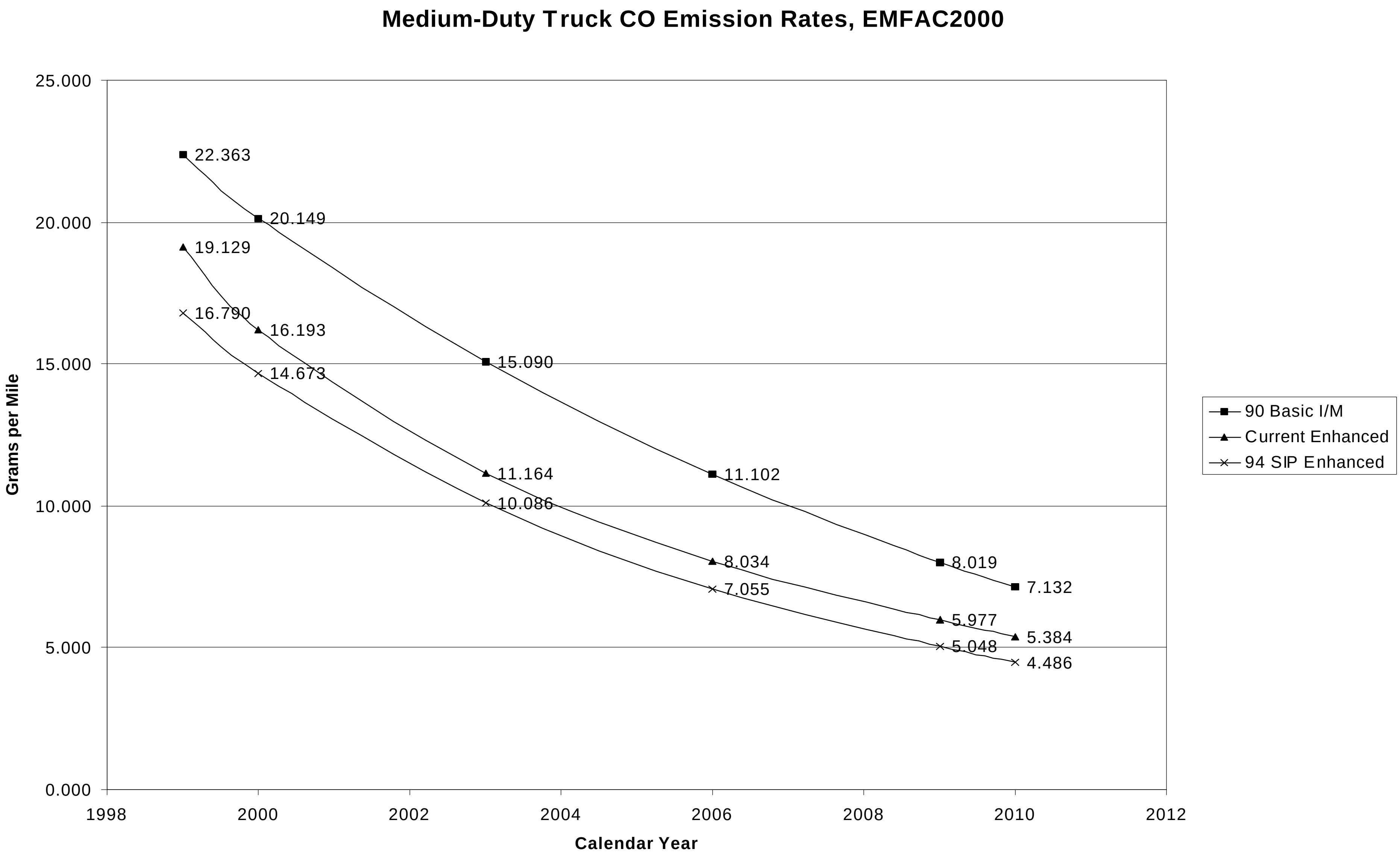

Medium-Duty Truck NOx Emission Rates, EMFAC2000
Grams per Mile
Calendar Year
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1998
2000
2002
2004
2006
2008
2010
2012
1.575
1.476
1.193
0.919
0.668
0.594
1.481
1.206
0.886
0.662
0.484
0.435
1.231
1.110
0.799
0.574
0.402
0.356
90 Basic I/M
Current Enhanced
94 SIP Enhanced

Figure IV-9


Medium-Duty Truck CO Emission Rates, EMFAC2000
25.000
20.000
15.000
10.000
5.000
0.000
Grams per Mile
1998
2000
2002
2004
2006
2008
2010
2012
Calendar Year
22.363
20.149
15.090
11.102
8.019
7.132
19.129
16.193
11.164
8.034
5.977
5.384
16.790
14.673
10.086
7.055
5.048
4.486
90 Basic I/M
Current Enhanced
94 SIP Enhanced